22:54:09 OCA PAD INITIATION - PROJECT HEADER INFORMATION 06/21/92

Active

Project #: E-20-X09 Cost share #: Rev #: 0
Center # : 10/24-6-R7513-0A0 Center shr #: OCA file #:
Work type : RES
Contract#: AGREEMENT DATED 6/8/92 Mod #: INITIATION Document : AGR
Prime #: Contract entity: GTRC

Subprojects ? : N CFDA:
Main project #: PE #:

Project unit: CIVIL ENGR Unit code: 02.010.116
Project director(s):
MARTIN C S CIVIL ENGR (404)894-2224

Sponsor/division names: PATTERSON PUMP COMPANY / TOCCOA, GA
Sponsor/division codes: 265 / 024

Award period: 920615 to 921030 (performance) 921030 (reports)

Sponsor amount	New this change	Total to date
Contract value	25,714.00	25,714.00
Funded	25,714.00	25,714.00
Cost sharing amount		0.00

Does subcontracting plan apply ?: N

Title: HYDRAULIC MODEL STUDY OF PUMP INTAKE STRUCTURE OF DORCHESTER LEVEE

PROJECT ADMINISTRATION DATA

OCA contact: Mildred S. Heyser 894-4820

Sponsor technical contact	Sponsor issuing office
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	TOCCOA, GA 30577

Security class (U,C,S,TS) : U ONR resident rep. is ACO (Y/N): N
Defense priority rating : supplemental sheet
Equipment title vests with: Sponsor GIT

Administrative comments -
PROJECT INITIATION

2

E-20-X09

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

NOTICE OF PROJECT CLOSEOUT

Closeout Notice Date 11/18/92

Project No. E-20-X09 Center No. 10/24-6-R7513-0A0

Project Director MARTIN C S School/Lab CIVIL ENGR

Sponsor PATTERSON PUMP COMPANY/TOCCOA, GA

Contract/Grant No. AGREEMENT DATED 6/8/92 Contract Entity GTRC

Prime Contract No.

Title HYDRAULIC MODEL STUDY OF PUMP INTAKE STRUCTURE OF DORCHESTER LEVEE

Effective Completion Date 921030 (Performance) 921030 (Reports)

Closeout Actions Required:	Y/N	Date Submitted
Final Invoice or Copy of Final Invoice	Y	
Final Report of Inventions and/or Subcontracts	N	
Government Property Inventory & Related Certificate	N	
Classified Material Certificate	N	
Release and Assignment	N	
Other	N	

Comments EFFECTIVE DATE 6-15-92. CONTRACT VALUE $25,714.

Subproject Under Main Project No.

Continues Project No.

Distribution Required:

Project Director	Y
Administrative Network Representative	Y
GTRI Accounting/Grants and Contracts	Y
Procurement/Supply Services	Y
Research Property Managment	Y
Research Security Services	N
Reports Coordinator (OCA)	Y
GTRC	Y
Project File	Y
Other HARRY VANN-FMD	Y
FRED CAIN-OOD	Y

FINAL REPORT

HYDRAULIC MODEL STUDY OF DORCHESTER LEVEE PUMP INTAKE STRUCTURE CITY OF GRAND PRAIRIE, TEXAS

by

C. Samuel Martin

Prepared for

PATTERSON PUMP COMPANY

Toccoa, Georgia

October 1992

GEORGIA INSTITUTE OF TECHNOLOGY
A UNIT OF THE UNIVERSITY SYSTEM OF GEORGIA
SCHOOL OF CIVIL ENGINEERING
ATLANTA, GEORGIA 30332

FINAL REPORT

HYDRAULIC MODEL STUDY OF DORCHESTER LEVEE PUMP INTAKE STRUCTURE

CITY OF GRAND PRAIRIE, TEXAS

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School of Civil Engineering

Georgia Institute of Technology

Atlanta, Georgia 30332

FOREWORD

A hydraulic model investigation of the Pump Intake Structure of the Dorchester Levee, City of Grand Prairie, Texas was conducted in the Hydraulics Laboratory of the School of Civil Engineering of the Georgia Institute of Technology.

The investigations were performed in the Hydraulics Laboratory of the Georgia Institute of Technology under the supervision of Professor C. S. Martin.

The model was constructed in the Shop of the School of Civil Engineering by Mr. Otis Tucker, Mr. Scott Williams, Mr. John Hutwanger, and Mr. Mingt Thein. The calibration of flow meters and the collection of model data were conducted by Mr. Thein under the supervision of Professor Martin.

The assistance and advice given by Mr. Jack Claxton of Patterson Pump Company in the course of the investigation is gratefully acknowledged.

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ABSTRACT

A hydraulic model study of the Pump Intake Structure of Dorchester Levee, City of Grand Prairie, Texas was conducted in the Hydraulics Laboratory of the School of Civil Engineering of the Georgia Institute of Technology. The model was constructed at an undistorted scale of 1:8 and operated on the basis of the Froude Law of hydraulic modeling. Tests were conducted to determine the flow pattern approaching the Pump Intake Bay and the velocity distribution within the intake bay itself.

Observations of the flow pattern utilizing dye injection and the shape of the free water surface were made at 150% of design flow. Detailed documentation of the flow distribution within the Pump Intake Bay was obtained by measurement of the velocity distribution, employing a miniature current meter.

The model performed very well hydraulically, with no indication of strong vortices within the Pump Bays.

There are recommendations for alteration of the design of the Pump Intake Structure.

LIST OF FIGURES

INTRODUCTION

A hydraulic model of the Pump Intake Structure of the Dorchester Levee, City of Grand Prairie, Texas was built in the Hydraulics Laboratory of the School of Civil Engineering of the Georgia Institute of Technology. The model was constructed at an undistorted scale of 1:8 and operated on the basis of the Froude Law of hydraulic modeling. The model was constructed from the laboratory floor up using plywood, wood, fiberglass, and Plexiglass materials. The model was built to scale using drawings furnished by Patterson Pump Company and Albert H. Halff Associates.

Tests were conducted to determine the flow pattern approaching the Pump Intake Bay and the velocity distribution within the intake bay itself. Observations of flow patterns were performed for various combinations of pumps operating at both high and low water intake levels.

In this report the consideration of model selection, model limitations, and the final choice of model scale will be initially discussed. A description of the construction methods, the testing procedures and the results will be presented.

HYDRAULIC MODELING LAW

For pump intake investigations the Froude Law is by far the most important in the prototype as the effects of viscosity and surface tension are considered negligible. The hydraulic model should be designed such that the effects of viscosity and surface tension do not affect its results. This is accomplished by choosing a model scale as small as possible. The Froude Law, which relates gravitational and inertial forces yields the following expressions for length ratios and flowrate ratios between prototype and model:

Scale Ratio: $L_R = L_P/L_M$

Head Ratio: $H_P = H_M L_R$

Flow Ratio: $Q_P = Q_M L_R^{2.5}$

For this 1:8 scale model, $L_R = 8$, and $Q_R = 8^{2.5} = 181$. This flow ratio was used for the setting of model flow rates, except that the maximum flow for the simulated model pumps was in accordance with accepted practice, 150% of that dictated by the Froude Law. Therefore, the flows for the simulated pumps were either 0.00552 of the prototype value (100%) or 0.00829 (150%).

MODEL DESCRIPTION

The design of the approach channel and the three pump intake bays is shown on Figures 1 and 2. Figure 1 is a plan view of the Intake Basin, while Figure 2 is a profile view of the Intake Bays or Pump Pits for Pumps B and C, respectively. In order to operate down to water levels as low as 416.0 ft, the bottom of the pump cell for Pump A is 412.0 ft. The design flow for Pump A is 5,000 gpm. For the other two pumps -- B and C -- the bottoms of the cells are set at elevation 413.0 ft. Each of these two pumps have a design flow of 10,000 gpm.

The Basin of Pump Intake Structure shown on Figure 1 was constructed out of plywood, structural wood, and fiberglass. Figure 3 is an oblique view of the Basin, the Pump Bays, and the siphon necessary to simulate the pumps. The walls of the Pump Intake Bay were constructed out of Plexiglass to view the water motion into and around the pump models. Water entered the Basin the model (rear part of Figure 3) through a 6-inch pipe containing six small 2.5-inch vertical pipes for flow distribution. The flow entering the Basin was smoothed out by a long vertical perforated plate. A weir-type gate with a height controlling mechanism was installed in the Head Tank of the upstream end of the model to set the water level required for each test. The three pumps were simulated by siphoning water at the required rate back into the laboratory sump. A view of the simulated pumps is indicated by the photograph of Figure 4.

The pump intake structure, consisting of dividing wall, outside pump structure wall, and discharge piping, was constructed out of Plexiglass. The suction bell curvature supplied by the manufacturer was molded from acrylic. A vortometer constructed of four radial vanes was mounted on a shaft with bearings in order to have a relative measure of vorticity and/or asymmetric flow through the three larger simulated pumps.

The operation of the model was accomplished as follows. By submerging the discharge end of the siphon the piping was primed by means of a vacuum pump. After a few minutes the siphon could be completely primed, allowing the required flow to be set using control valves on each siphon. The flow could be set to 100% or 150% pump capacity by adjusting each valve until the proper flow rate was attained.

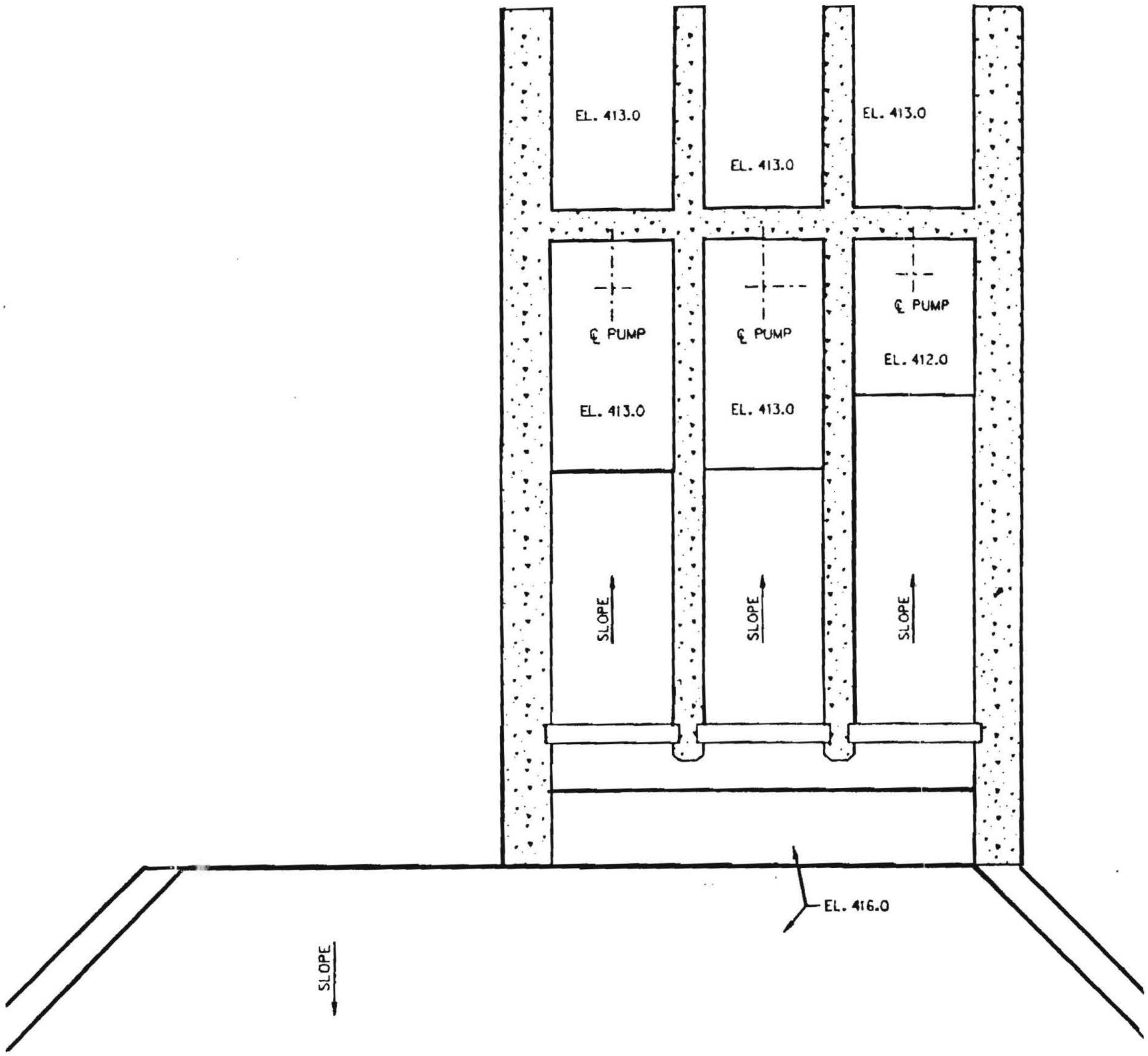

Figure 1. Plan View of Pump Intake Design

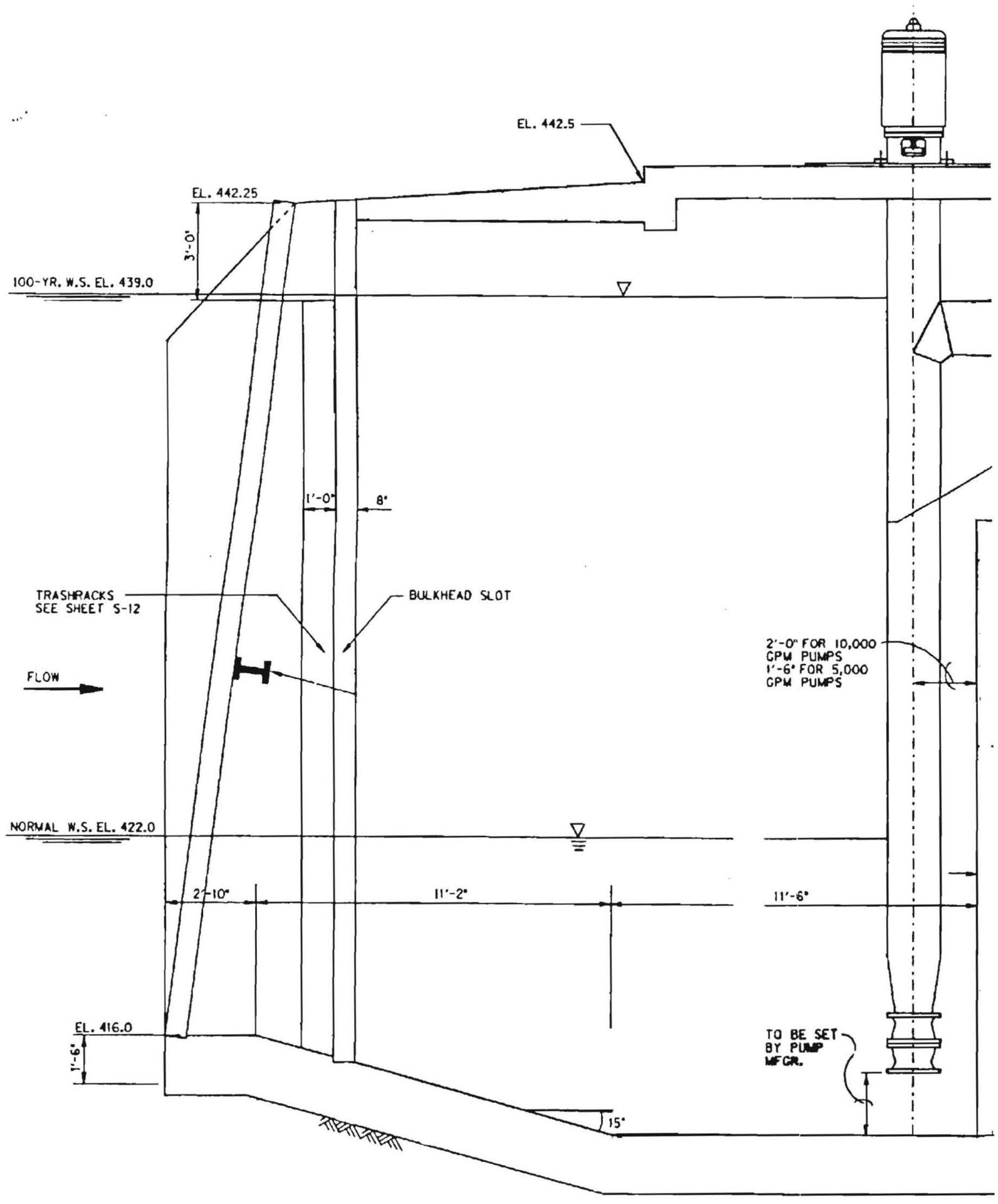

Figure 2. Profile View of Pump Intake Design for Pump Bays B and C

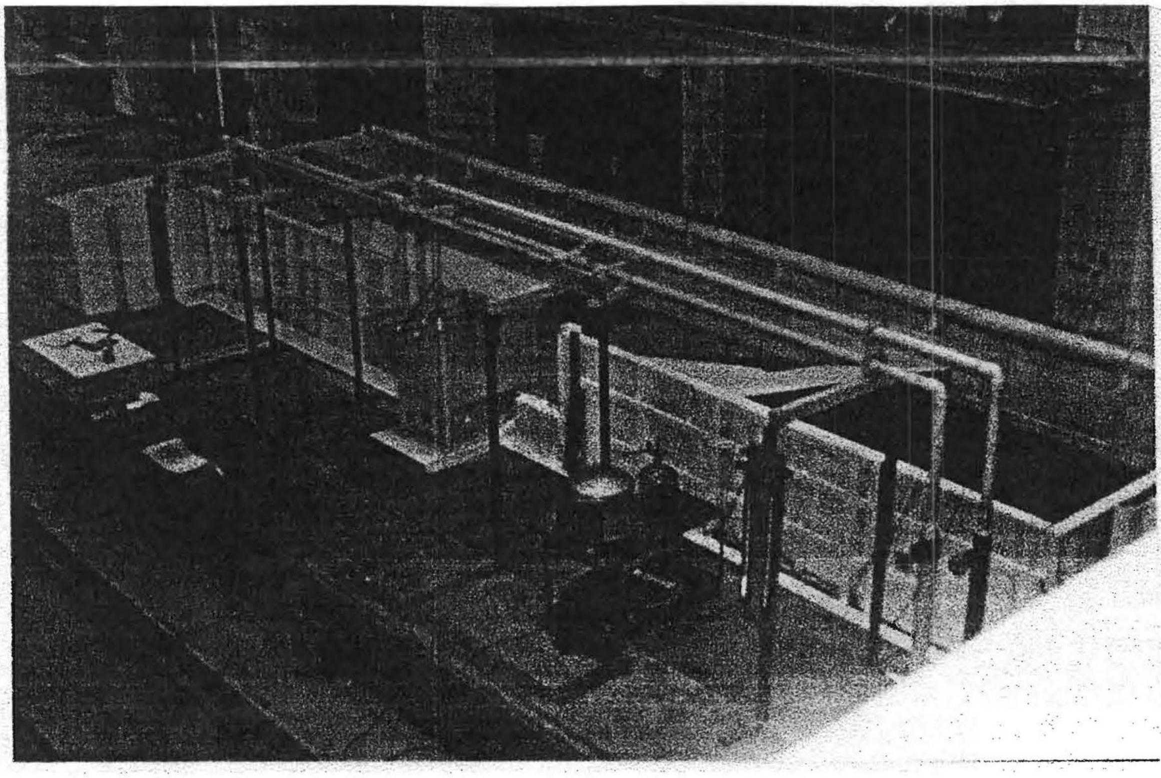

Figure 3. Oblique Photograph of Model

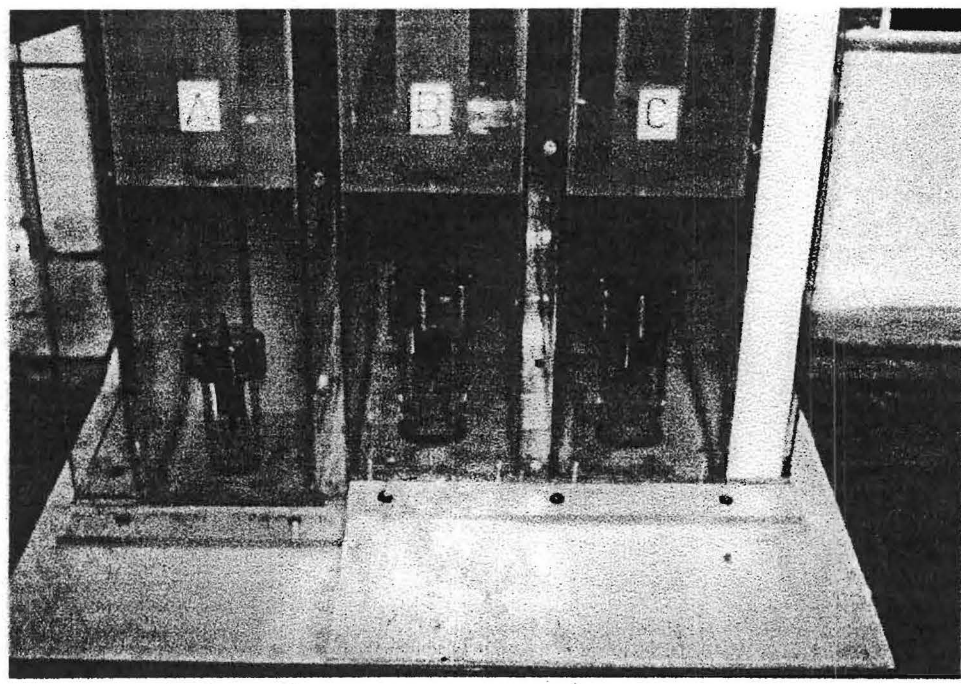

Figure 4. Front View of Model Pumps

MEASURING EQUIPMENT

The model consisted of a sump, pumps, distributing pipes with flow-control valves and flow meters. The flow measuring devices used for the model were of the differential-pressure type -- elbow meters. These flow meters were calibrated in situ utilizing a weir in the Hydraulics Laboratory.

The flow through each pump was determined by the use of differential air-water manometers connected to each elbow meter. The pump effluent was measured by the elbow meters on the discharge of the model pumps in the siphon. For the model the water level was set and monitored with scales attached to the walls of the Basin and the Pump Intake Bays.

A miniature current meter was utilized to measure the distribution of velocity within the Pump Intake Bay. This propeller-type meter was calibrated in an horizontal flume with known velocities.

TEST RESULTS

The plan and profile of the Pump Intake design tested are shown on Figures 1 and 2. Figure 1 and 2 illustrate the details of the Pump Intake Structure and the two pump pits. The inside floor of the Basin was placed at elevation 416.0 ft. The range of water level elevations in the Pump Basin to be tested varied from 422.0 ft (minimum for Pumps B and C) to 439.0 ft (maximum for all three pumps). Inasmuch as there was minimal vortometer rotation and free surface disturbance at the maximum water surface elevation of 439.0 ft, the majority of the tests were conducted at the minimum elevation of 422.0 ft for the two large pumps. Moreover, the flows were generally set at 150% in order to investigate any possible scale effect related to the relaxation of the Reynolds number law.

Observations

Initial testing was conducted, principally at the normal water elevation of 422.0 ft, for the purpose of visualizing rotation of the vortometers, water level difference across the intake, and dye patterns indicating flow distribution. Indeed, most of the testing for the initial design was observational and qualitative. For these tests the individual pump flows were set at the nominal rates of 10,000 gpm (100% for Pumps B and C) or 15,000 gpm (150% for Pumps B and C). For Pump A the corresponding flows were 5,000 gpm and 7,500 gpm, respectively.

Initially, exploratory tests were run by visualizing dye patterns and direction and severity of rotation of the vortometers installed in the Pump Bays of two larger pumps B and C. Various combinations of three, two, and single pump operation were tested at 100% and 150% flow and at intake levels of 422.0 ft and 439.0 ft. Figure 5 illustrates the dye pattern for flow approaching the Pump Bays for Pumps A, B, and C operating at 150% capacity. The flow pattern in the approach was generally uniform across the intake.

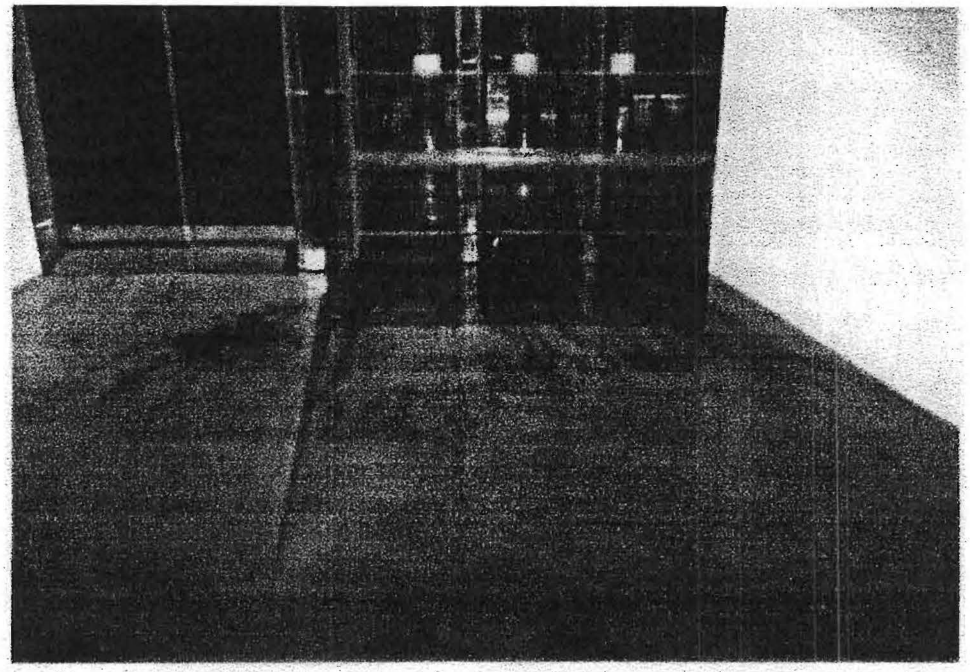

Figure 5. Distribution of Dye In Approach for Pumps A, B, and C Running (150% Design Flow and Water Elevation 422.0 ft)

Observations of vortometer activity were made for three pump, two pump, and single pump operation with the water level at 422.0 ft and at 150% capacity. Hence, there were four combinations of pumps -- A, B, and C ; B and C; B; and C.

For all three pumps operating at 150%, the vortometers very seldom turned. The turning was sporadic and intermittent. For example, Vortometer A would stop rotation for 12 seconds (prototype units), turn counterclockwise for 2 seconds, then stop for another 12 seconds, followed by another similar cycle. Vortometer B tended to go through a cycle of no motion for 6 seconds, counter clockwise motion for 4 seconds, no motion for 8 seconds, counterclockwise motion for 1 second, followed by no motion for 8 seconds. For Vortometer C the motionless period was

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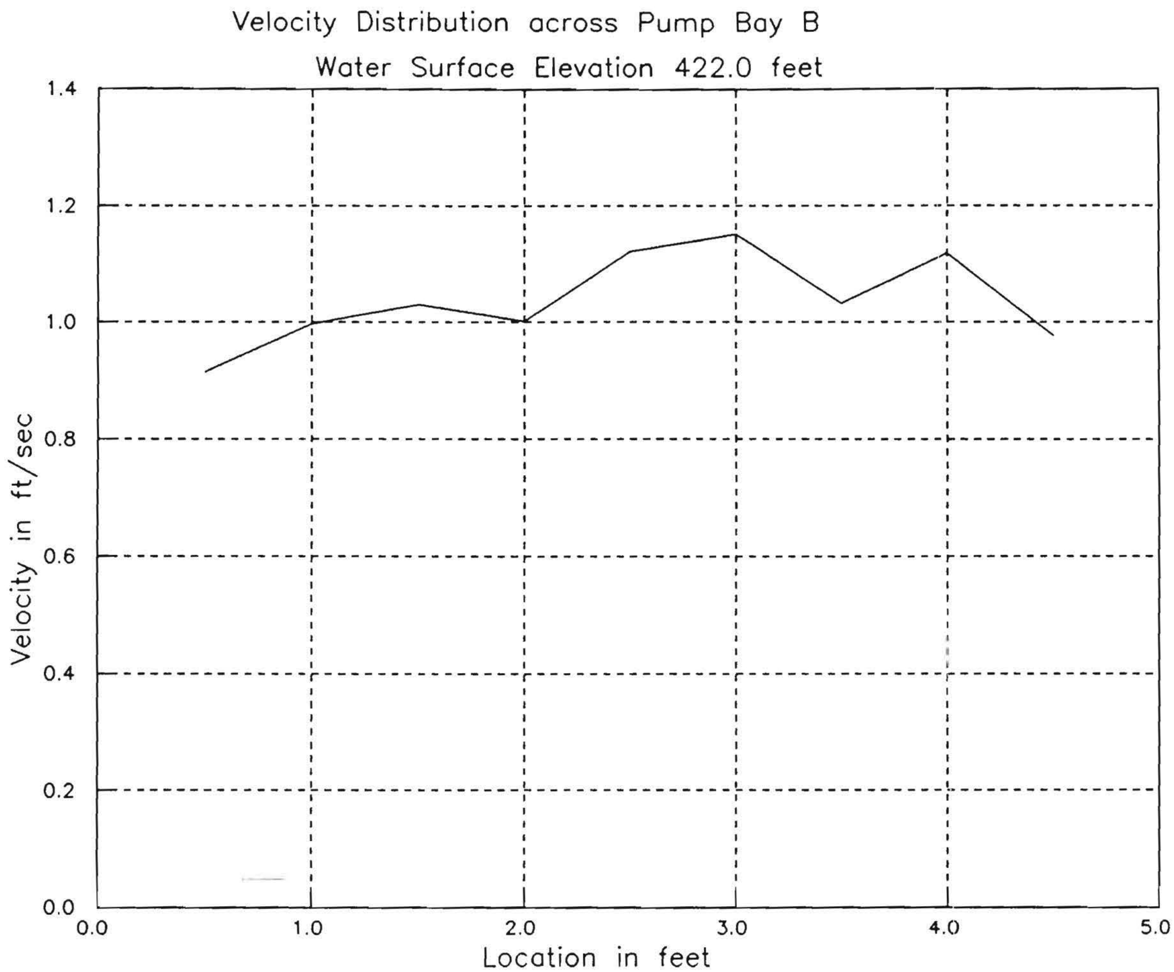

Figure 6. Velocity Distribution within Pump Intake Bay B with Pumps A, B, and C Running (150% Design Flow and Water Elevation 422.0 ft)

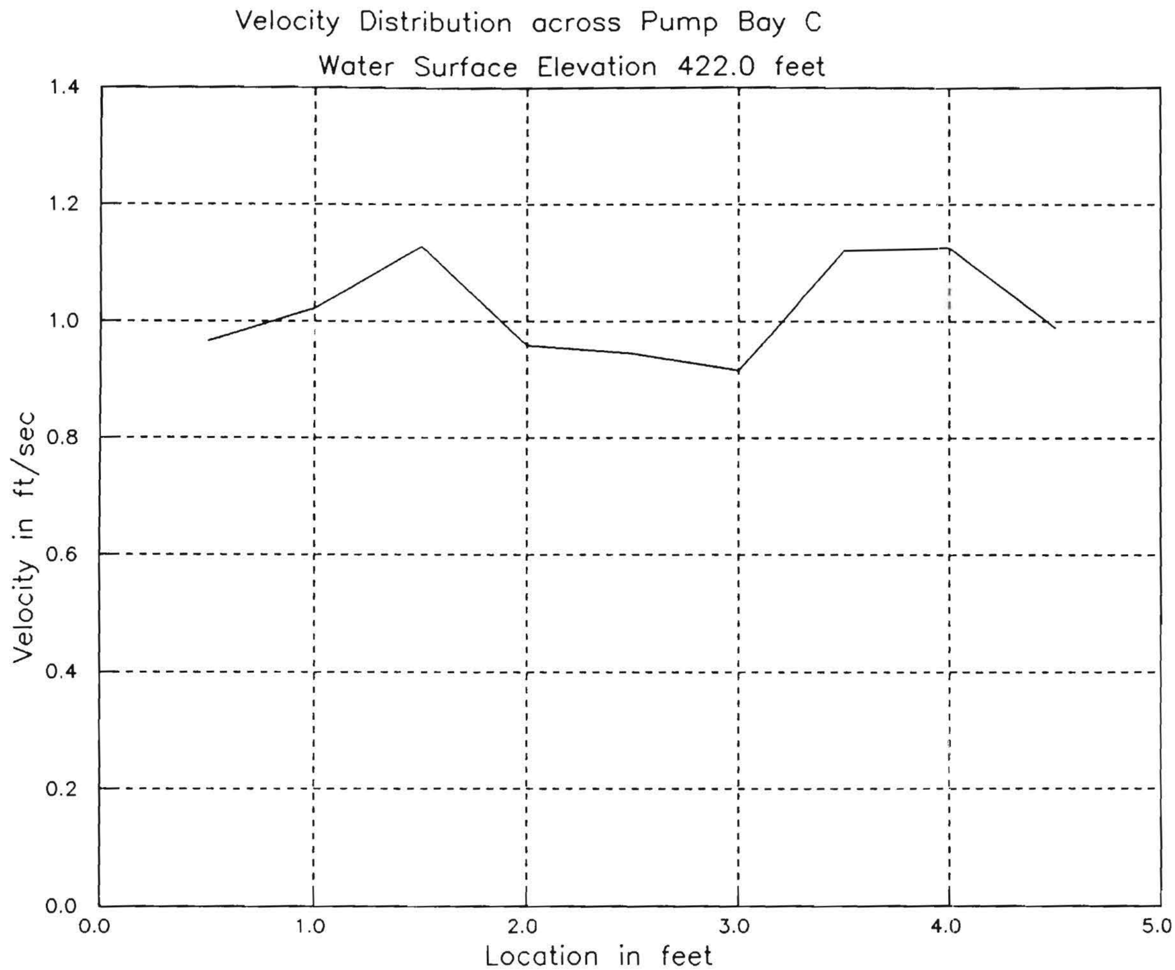

Figure 7. Velocity Distribution within Pump Intake Bay C with Pumps A, B, and C Running (150% Design Flow and Water Elevation 422.0 ft)

For two pump operation (Pumps B and C) the velocity distribution is somewhat skewed, as shown by Figures 8 and 9. Finally, Figures 10 and 11 show the velocity distribution for operation of Pumps B and C, respectively.

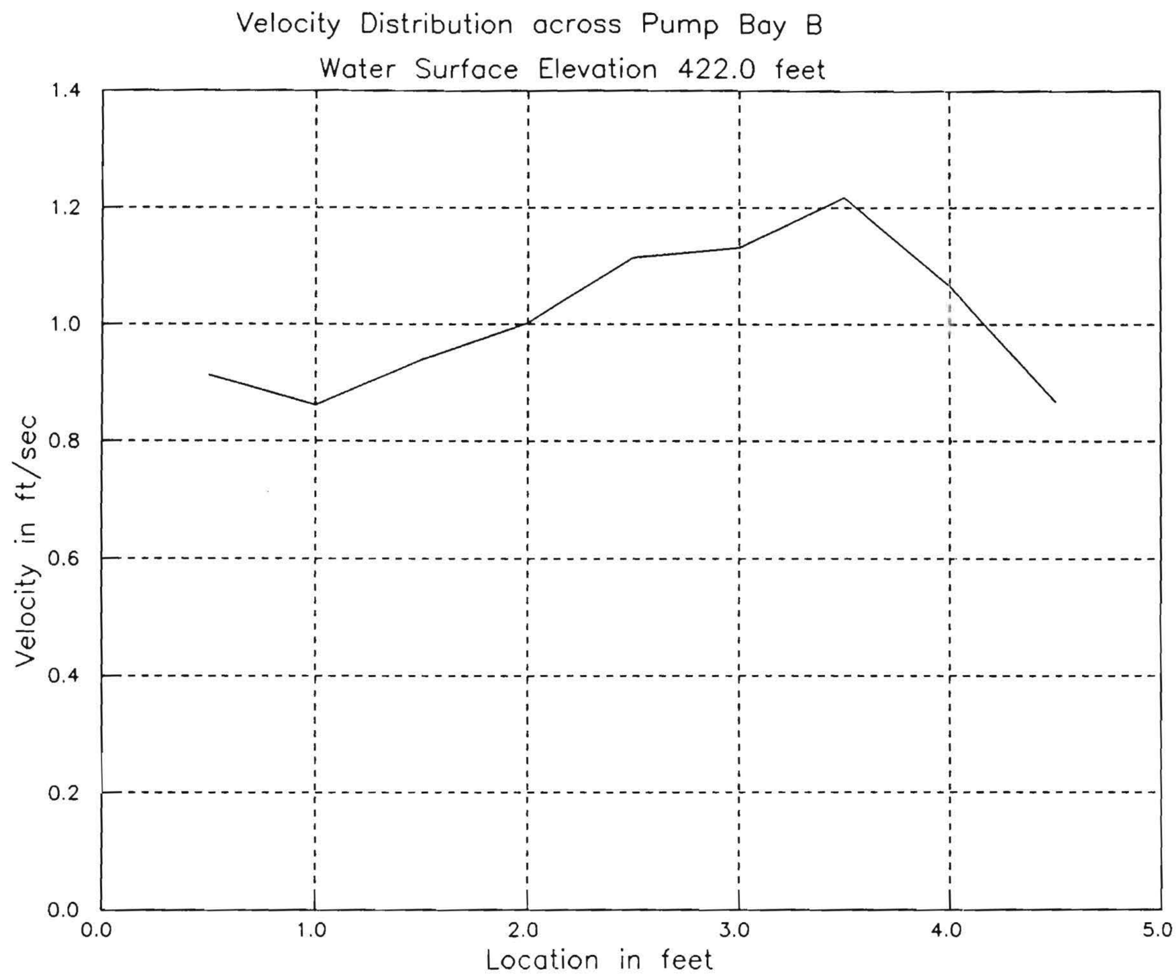

Figure 8. Velocity Distribution within Pump Intake Bay B with Pumps B and C Running (150% Design Flow and Water Elevation 422.0 ft)

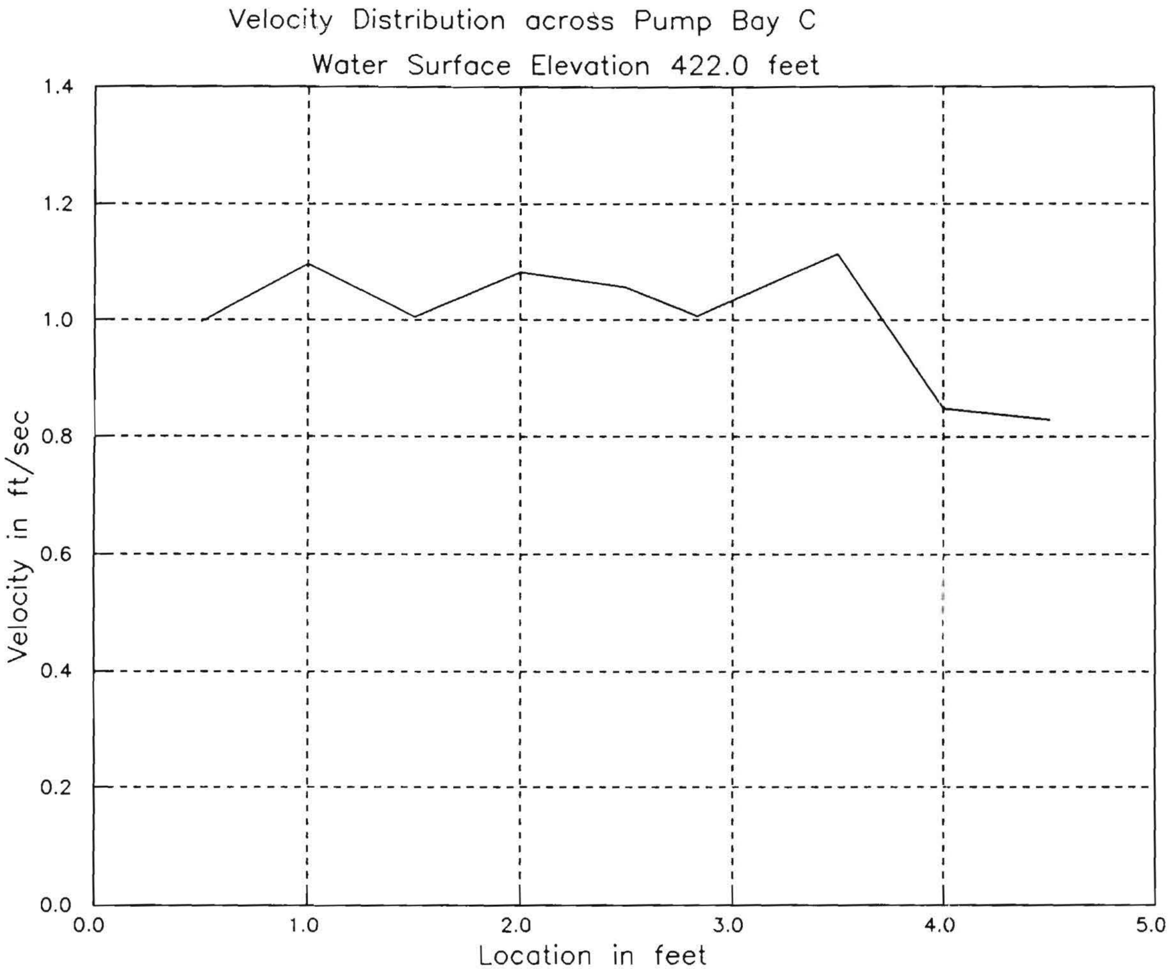

Figure 9. Velocity Distribution within Pump Intake Bay C with Pumps B and C Running (150% Design Flow and Water Elevation 422.0 ft)

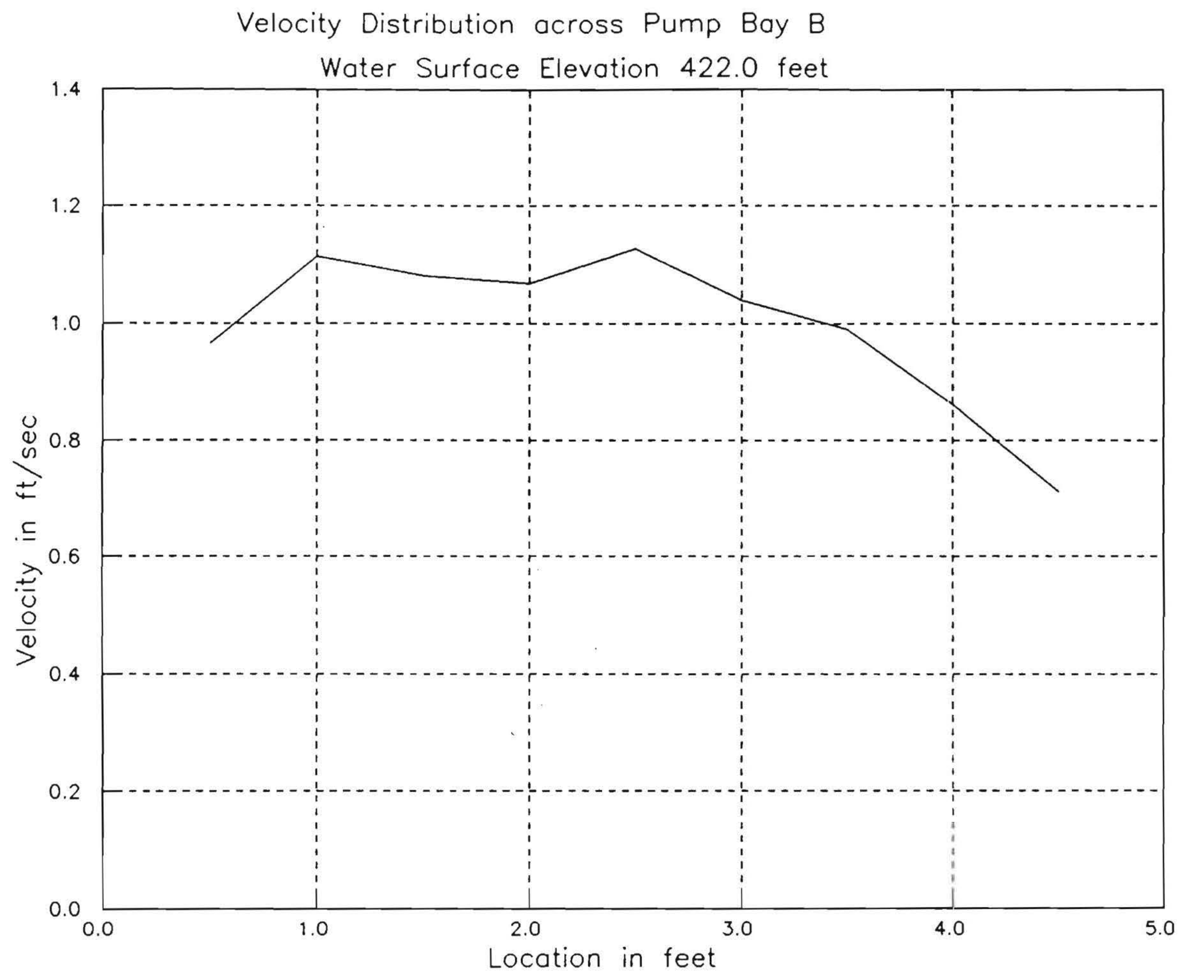

Figure 10. Velocity Distribution within Pump Intake Bay B with Pump B Running (150% Design Flow and Water Elevation 422.0 ft)

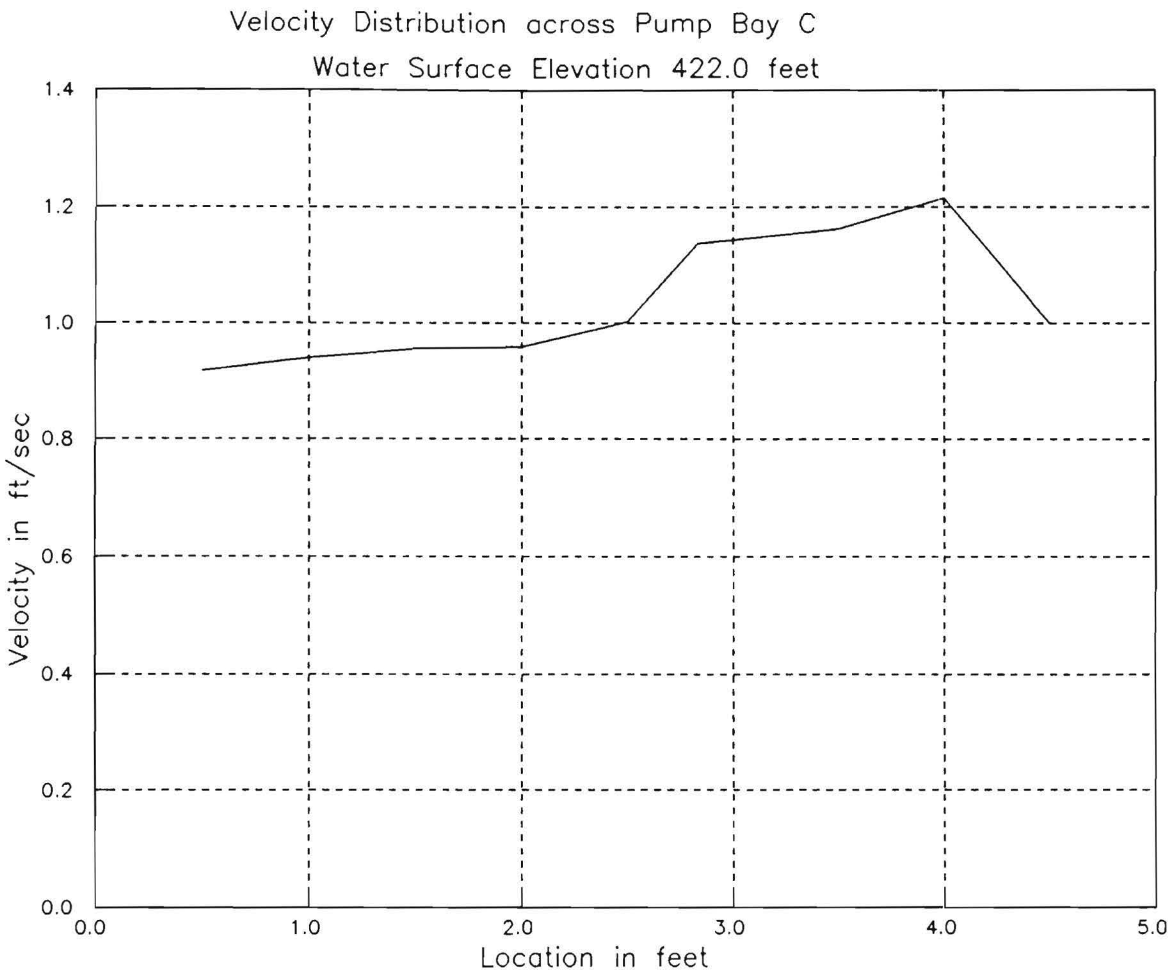

Figure 11. Velocity Distribution within Pump Intake Bay C with Pump C Running
(150% Design Flow and Water Elevation 422.0 ft)

CONCLUSIONS

The hydraulic model study of the Dorchester Levee Pump Intake Structure showed that the flow into the pump bays was relatively uniform for three, two, and one pump operation. There was no significant vortex activity under the range of operating conditions as severe as three pumps running at 150% of design flow and at the lowest intake water level of 422.0 ft.

Because of relatively uniform flow and no vortex activity on the free surface, there are no recommendations for design modifications of the structure.